BRIDGES IN OHIO

By W. E. BURROUGHS, C. E. 4.

The old wooden covered bridge which has for so long been a feature of the Ohio landscape is fast disappearing. The covered wooden bridge, which, in the time of the horsedrawn vehicle proved a safe refuge for the traveler in time of storm, has outlived its usefulness. The fundamental idea in covering the bridge was to protect the timbers from weather. Its strength and roadway width is too inadequate for the demands placed upon it by present day traffic; and so, regardless of sentiment, it must pass into the obsolete.

Another old type of bridge that is also doomed is the famous "S" bridge. This bridge, built entirely of stone blocks to form a stone arch, has an interesting history. Legend has it that the architect, peeved at the engineer, designed this type so that it would be hard to construct. The fact is that the design was the only practical one. The bridge being on a skew, each block would have to have been cut perfectly to fit in place. By the use of stereotomy the dimensions could have been figured, but as they were cut by hand, and so imperfectly, too much cost would have been entailed to build them to fit the skew. The photograph, taken when snow was on the ground, shows that only one lane of traffic is possible over the bridge at one time. It is a typical "S" bridge, built about 1830, repaired in 1913, and its historical appeal has permitted its virgin freakishness to go untouched through these late years of remodeling. This bridge is on the National Road, U. S. Route 40, west of Hendrysburg, in Belmont county.

The designing of the graceful, wide, and sturdy bridges seen along the highways of Ohio today instead of the weak, narrow, and poorly aligned ones of other days is the work of the Bureau of Bridges of the Department of Highways of the State of Ohio.

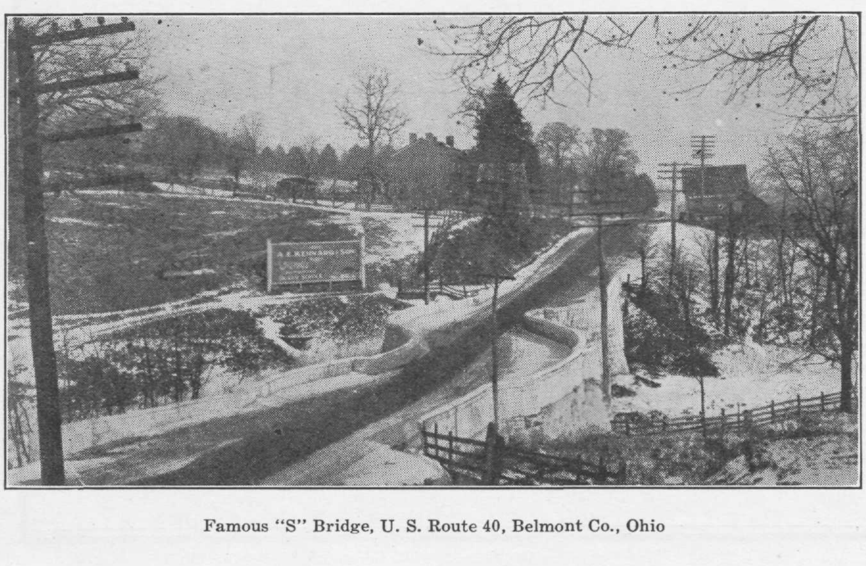
When the expediency of a certain project has been ascertained and a common agreement to right of way and distribution of cost has been reached, then the project has received its first impetus. A careful survey is made and then drawn up in the resident engineer's office. This drawing is called a site plan and constitutes the first step toward actual design. Borings are also made to find out the condition of subsoil and to determine the kind of foundation that the bridge footings will rest on.

The type of soil determines the allowable stress in pounds per square foot that the soil will support. Most subsoils in Ohio can be calculated upon as being able to support 4,000 pounds per square foot without the use of piling or other reinforcement.

When the site plan has reached the Bureau of Bridges, then it is up to the designing engineer to design the most economical and best bridge for the project. Standard plans that have already been approved serve as an aid and guide in the design. The type of bridge that is best suited to the data given by the site plan selected may be one of several, concrete arch, concrete slab, concrete deck cantilever, concrete beam, concrete girder, steel girder or steel truss. The length of span, height needed, foundation, and money available determine the type.

Of the different types mentioned, the concrete arch is the most graceful and beautifying to the landscape; but, unfortunately, it has its restrictions. It is preferable that an arch bridge have its footings rest on solid rock. Since the horizontal thrust, characteristic of an arch makes it impracticable for it to be built on poor subsoil, it is more expensive; and the height must be enough to make it practicable.

Arches differ from most types in that they are statically indeterminate, i.e., they cannot be calculated by the ordinary principles of mechanics. Generally arches are placed monolithically and reinforced for bending stresses. The elastic theory, which is generally used for this design, is based upon the assumption that both the concrete and steel are elastic materials within the given working stresses.

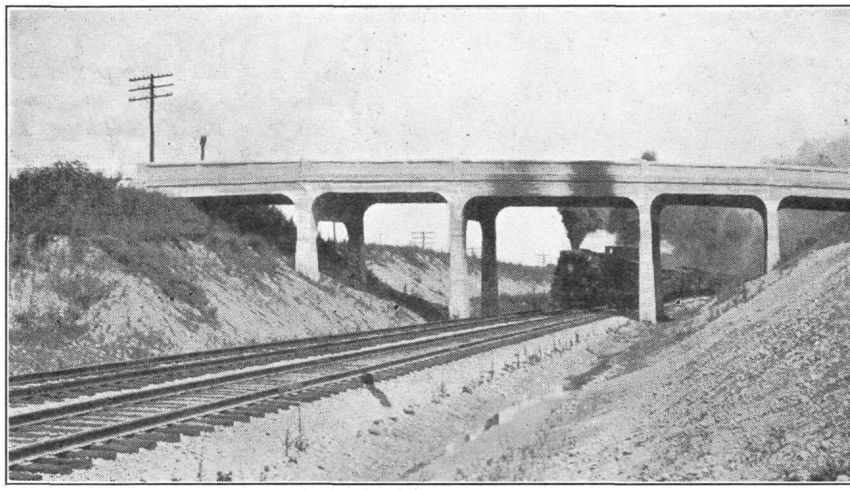


Famous "S" Bridge, U. S. Route 40, Belmont Co., Ohio

Most arches today are of the hingeless type and must be designed to carry the stresses due to changes in temperature as well as to dead load, live load, and impact.

The shape of the arch depends upon the ratio of rise to span and upon the distribution of loads, most arches being made of such a shape that the thrust line follows the center of the rib for dead load only.

As a help to the National Committee of the American Society of Civil Engineers on "Concrete and Reinforced Concrete Arches," observations were made during construction on the Conneaut viaduct, the Miami River bridge at Piqua, and the Ashtabula viaduct, to assist in studying the behavior of arches and their supporting piers under varying temperatures, loads, and foundation conditions.



Grade Separation, Route 55, Urbana, Ohio

This Bureau has also conducted extensive tests on the action of arch bridges by means of elastic models and Beggs deformeter gages. Cardboard models were made of the Ashtabula viaduct, both with and without the spandrel columns and the deck, and microscopic deflections were measured to determine the effect of the floor system on the arch ribs when acting monolithically. These observations indicate that the floor system materially affects the behavior of the arch rib on such a structure.

The seven 95-ft. clear span arch bridge across the Maumee river at Napoleon is a good example of the imposing spectacle that an arch presents. This bridge was designed by D. H. Overman under the supervision of J. R. Burkey, chief engineer, and W. H. Rabe, chief designing engineer, of the Bureau of Bridges, State Department of Highways. This structure is a spandrel-filled, reinforced concrete arch with seven 95-foot clear spans, a 36-foot roadway and two five-foot sidewalks; total length, 750 feet. Its foundation rests on solid rock 50 feet below the sidewalks and approximately 20 feet below normal water level. Granulated slag, solidified with pneumatic tampers, was used for filling over the arches, enabling the builders to construct the pavement immediately without danger of appreciable settlement. This project involved the excavation of 18,000 cubic yards of earth, hardpan, and rock, the mixing and distribution of 11,000 cubic yards of concrete, requiring 67,412 sacks of cement, and the placing of 460,000 pounds of reinforcing steel in addition to lesser quantities of other materials. In recognition of the growing importance of identifying municipalities from the air for the benefit of aviators, the word "Napoleon" is boldly outlined in the brick pavement on the bridge in light-colored bricks against the darker background. The total contract price for the bridge and approaches was $335,880.30. It was dedicated September 18, 1930, by Myers Y. Cooper, Governor of Ohio, Robert N. Waid, Director of Highways, and Frank L. Raschig, First Assistant Director.

Expansion due to temperature changes must be taken care of, although expansion in an arch is taken care of in the arch itself, expansion in other types must be taken care of by different means. On a concrete beam bridge one end is fixed while the other end is left free to move. On the bottom of the beams are placed phosphor bronze bearing-plates. These plates are made level with the face of the beam. Directly under the beams on the abutment bridge seat are placed similar plates. These plates are also used on the concrete girder type. The expansion in a steel bridge is taken care of by having the bridge set on cast iron rockers. The lineal expansion on a bridge may be said to be 1 inch in 80 feet per 100 degree change in temperature.

Camber is required in bridges of over one span to prevent the bridge from sagging in the center. The total clear span divided by 700 determines the difference in elevation that shall be between the middle pier and the abutment.

The type of railing is taken from standard plan. It is desirable that as many different types of railing shall be used on the same route as possible. This gives a more varied and pleasing appearance.

In the design of a continuous slab bridge, negative steel must be put in the slab over the pier to take care of the negative reactions.

When one considers that there are 11,500 miles of state highways in Ohio and nearly 6,000 stream crossings, each requiring a bridge, one realizes the extent of the work of the Bureau of Bridges.

EDITOR'S NOTE: These photographs are offered through the courtesy of Mr. J. R. Burkey, Chief Engineer of Bridges, Bureau of Bridges, State Highway Department of Ohio.